BABU BANARASI DAS UNIVERSITY, LUCKNOW
School of Engineering
(School Code: 04)
Department of Electrical Engineering
Master of Technology
(University Branch Code: 50)
[Full Time]
(Power System & Control)

Credit Summary Chart:

Credit Summary Chart						
Course Category	**Semester**				**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**		
GE	4	8			12	12.77
C	19	15	20	28	82	87.23
Total	**23**	**23**	**20**	**28**	**94**	**100**

Discipline wise Credit Summary Chart						
Course Category	**Semester**				**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**		
Basic Sciences	4	4			**8**	**8.51**
Humanities and Social Sciences					**0**	**0.00**
Engg. Sciences					**0**	**0.00**
Professional Subject Core	14	9			**23**	**24.47**
Professional Subject - Generic Elective	4	8			**12**	**12.77**
Professional Subject -Open Elective					**0**	**0.00**
GP + Project Work, Seminar and / or Internship in Industry or elsewhere.	1	2	20	28	**51**	**54.25**
Total	**23**	**23**	**20**	**28**	**94**	**100.00**

Master of Technology
[Full Time]
(Power System & Control)

Evaluation Scheme:

1st YEAR SEMESTER I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS3106	Applied Mathematics	3	1	0	40	60	**100**	**4**
C	MEE3101	Advanced Power System Analysis	3	1	0	40	60	**100**	**4**
C	MEE3102	Modeling & Simulation	3	1	0	40	60	**100**	**4**
C	MEE3103	Advanced Control System	3	1	0	40	60	**100**	**4**
GE		**Generic Elective I**	3	1	0	40	60	**100**	**4**
C	MEE3151	Power System Lab	0	0	2	40	60	**100**	**1**
C	MEE3152	Modeling & Simulation Lab	0	0	2	40	60	**100**	**1**
C	MEE3153	Seminar	0	0	2	100		**100**	**1**
Total			**15**	**5**	**6**	**380**	**420**	**800**	**23**

1st YEAR SEMESTER II									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS3104	Optimization Techniques	3	1	0	40	60	**100**	**4**
C	MEE3201	Application of AI in power & control	3	1	0	40	60	**100**	**4**
C	MEE3202	Economic operation & control of power System	3	1	0	40	60	**100**	**4**
GE		**Generic Elective II**	3	1	0	40	60	**100**	**4**
GE		**Generic Elective III**	3	1	0	40	60	**100**	**4**
C	MEE3251	Artificial Intelligence Lab	0	0	2	40	60	**100**	**1**
C	MEE3252	Mini Project	0	0	2	100		**100**	**1**
C	MEE3253	Research Methodology & Practices$	0	0	2	100		**100**	**1**
Total			**15**	**5**	**6**	**440**	**360**	**800**	**23**

$ The mission of the cource is to impart research skills to the skills to the begineers and help them to improve the quality of research. The student is expected to develop most appropriate methodoligies for their research studiesand then give a presenntation on researchoverview and its methodoligies. This may include various steps to conduct the research.

2nd YEAR SEMESTER III									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MEE3351	State of the Art Seminar*	-	-	-	200	-	**200**	**4**
C	MEE3352	Thesis-I#	-	-	-	400	-	**400**	**16**
Total			**-**	**-**	**-**	**600**	**-**	**600**	**20**

***The Student need to perform a literature survey, give a state of art presentation and will submit a synopsis clearly mentioning the problem statement. The presentation ans synopsis will be evaluated internally within two months of the start of the semester and result will be intimated to the student so as to proceed for the thesis-I.**

#The student will develop a workable model for the problem that has been proposed in synopsis.

2nd YEAR SEMESTER IV									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MEE3451	Thesis-II##	-	-	-	200	800	**1000**	**28**
Total			**-**	**-**	**-**	**200**	**800**	**1000**	**28**

##This is in continuation with thesis-I. The required experimental/mathematical verification of the proposed model will be done in this semester.

Generic Elective:

Course Code	Generic Elective-I
GE35011	Deregulation of Power System
GE35012	High Voltage D. C. Transmission system
GE35013	Digital Signal Processing & its Applications
GE35014	Smart Grid
Course Code	**Generic Elective-II**
GE35021	Flexible AC Transmission System (FACTS) Controllers
GE35022	Advanced Power system Protection
GE35023	Power Quality
GE35024	Power System Dynamics & Control
Course Code	**Generic Elective-III**
GE35031	Industrial Drives & Control
GE35032	Robust & Adaptive Control
GE35033	Intelligent Instrumentation
GE35034	Robotics

Legends:

L Number of Lecture Hours per week
T Number of Tutorial Hours per week
P Number of Practical Hours per week
CIA Continuous Internal Assessment
ESE End Semester Examination

Category of Courses:

F Foundation Course
C Core Course
GE Generic Elective
OE Open Elective

Master of Technology
(Power System & Control)

SEMESTER – I

MEE3101 ADVANCED POWER SYSTEM ANALYSIS

Course Objective:

1. To develop a strong foundation in the field advanced power system.
2. The subject gives the deep knowledge about advanced power system analysis.

Learning Outcome:

At the end of the course, student should be able:

1. To understand about advanced power system.
2. To understand the concepts of advanced power system analysis.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to power system Analysis:** Single line diagram, Per unit system, Static modeling of power system components. **Fault Studies**: Analysis of balanced and unbalanced three phase faults, Fault **c**alculations, Short circuit faults, Open circuit faults.	30 Hours	1
II	**Transient Stability analysis:** Swing Equation, Equal area criterion, Multi-machine stability. **Small Signal Stability**: Modal Analysis, Participation Matrix, Design of Power System.	30 Hours	1
III	**Voltage Stability:** Sensitivity analysis, Real time voltage stability analysis methods. **Introduction to load flow problem:** Network admittance matrix formulation, Gauss Seidel method of load flow, Newton Raphson method, Decoupled and Fast decoupled Load flow, DC load flow, Distribution load flow.	30 Hours	1
IV	**Security Analysis:** Power system states, Power system security, Contingency analysis, Linear sensitivity factors, Generation shift distribution factor, Outage	30 Hours	1

	distribution factor. **Advanced topics in power system:** Introduction to Synchro-phasors and its applications in powers system monitoring & control.		

Text & Reference books:

1. 'Power System Analysis' by Grainger, J.J. and Stevenson, W.D., Tata McGraw Hill, New Delhi.
2. 'Computer analysis of power systems' by Arrillaga, J and Arnold, C.P. John Wiley and Sons.
3. 'Computer Techniques in Power System Analysis' by Pai, M.A. Tata McGraw hill.
4. 'Power system analysis' by Nagrath and Kotari.

MEE3102 MODELING & SIMULATION

Course Objective:

This course provides an overview of models and simulations and of modeling and simulation techniques. Techniques include time-driven and event-driven dynamic models/simulations, Monte Carlo simulation, and decision simulation. The course addresses the role of modeling and simulation in the systems engineering process and provides methods for architecting and managing the development of complex models/simulations.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the variety of different types of models and simulations and the different ways in which they are used.
2. To understand the role of modeling and simulation in the systems engineering process, how to manage the development of complex models and simulations, and how to use the systems engineering process to develop complex models and simulations
3. To understand key development factors associated with developing complex models and simulations, the factors that determine what level of detail is appropriate for a model/ simulation, and the evolution of a model/simulation.
4. To use MATLAB to develop and graph simple mathematical models of systems, translate these into simple dynamic time-driven simulations, discrete event simulations, and Monte Carlo simulations, and develop simple intelligent agents.
5. To develop a plan for the development of a distributed simulation, a design for a simple distributed simulation, and work as part of a team to develop, integrate, verify and validate prototype modules for a distributed simulation.

Course Contents:

Module	Course Topics	Total Hours	Cre dits
I	**Introduction:** Definitions of Modeling and Simulation, Applications, Terminology & Components, Discrete vs. Continuous time, Process flow in simulation study, Review of Basic Probability and Statistics Terminology and Concepts, Useful Statistical Models, Distributions.	30 Hours	1
II	**Queuing models:** Characteristics, Performance Measures, Steady-State Behavior, Networks of Queues, Properties of Random Numbers, Generation of Pseudo-Random Numbers, Testing for Randomness, Pitfalls.	30 Hours	1
III	**Input Modeling:** Collecting Data, Identifying Distribution, Histograms, Parameter Estimation, Goodness-of-Fit Selecting Input Model without Data**,** Model Building, Verification, and Validation, Verification of	30 Hours	1

	Simulation Models, Calibration and Validation of Models.		
IV	**Output Analysis:** Types of Simulations with Respect to Output Analysis, Stochastic Nature of Output Data, Measures of Performance Output Analysis for Termination Simulations, Output Analysis for Steady-State Simulations**,** Simulation Examples: Power Systems, Simulation Examples: Control Systems.	30 Hours	1

Text Books:

1. Simulation Modeling and Analysis by Averill M. Law,
2. Theory of Modeling and Simulation, by Bernard P. Zeigler, Herbert Praehofer , Tag Gon Kim ,

MEE3103 ADVANCED CONTROL SYSTEM

Course Objective:

1. The course is designed to provide students with an understanding of linear system as well as non-linear system concepts.
2. Course emphasizes the state space approach and designing of pole placement and state observer design.
3. To check the stability of any autonomous system by using Lyapunov's approach.
4. To understand the concept of non-linear systems and describing functions.

Learning Outcome:

1. To analyze dynamics of a linear system by solving system model/equation or applying domain transformation.
2. To realize the structure of a discrete time system and model its action mathematically.
3. To examine a system for its stability, controllability and observability.
4. To Examin the stability of an autonomous system with the help of Lyapunov's stability theory.
5. To understand the concepts of non-linear control techniques.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**State Space Analysis:** Introduction, Concept of state, State Variable and State Model, State models for linear and continuous time systems, Solution of state and output equation, controllability and observability, Pole Placement, State observer Design of Control Systems.	30 Hours	1
II	**Analysis of Discrete System:** Discrete system and discrete time signals, State variable model and transfer-function model of discrete system, Conversion of state variable model to transfer function model and vice-versa. Modeling of sample hold circuit, solution of state difference equations. Steady state accuracy. Stability on the z plane and Jury stability criterion, bilinear transformation, Routh-Hurwitz criterion on rth planes.	30 Hours	1
III	**Stability Analysis:** Introduction**,** Stability in the sense of Lyapunov, Lyapunov's stability theorem, Lyapunov's instability theorems, Direct method of Lyapunov for the Linear and Nonlinear continuous time autonomous systems.	30 Hours	1

IV	**Nonlinear Control Techniques:** Introduction to nonlinear systems, Types of nonlinearities, Describing function, describing function analysis of nonlinear control systems, Sliding mode control, Feedback linearization methods.	30 Hours	1

Text &Reference Books:

1. 'Digital Control and State Variable Method' by M. Gopal.
2. 'Systems and Control' by S.H. Zak, Oxford University. Press.
3. 'Digital Control System' by B C Kuo.
4. 'Control System' by B.N. Sonkar, PHI.

MEE3151 POWER SYSTEM LAB

1. Formation of Y-BUS matrix using MATLAB coding.
2. MATLAB coding N-R Load flow in polar co-ordinates.
3. Load flow calculation using MATLAB and PST package.
4. Optimal power flow using PSAT.
5. Distribution load-flow.
6. Symmetrical and unsymmetrical fault studies.
7. Small signal stability analysis using MATLAB and PST package.
8. Transient stability analysis using MATLAB and PST package.
9. State Estimation using MATLAB program.
10. Power quality calculation using PSCAD/EMTDC.
11. Time-domain simulation in PSCAD for observing various power systems scenarios like power swing, voltage instability etc.

MEE3152 MODELLING & SIMULATION LAB

1. Study of MATLAB toolboxes:
   i. Power system toolbox.
   ii. Control System toolbox.
   iii. Neural network toolbox.
   iv. Use of MATLAB functions block for linking m-file with Simulink model.
   v. Signal Processing toolbox.
   vi. Modeling of Wind Turbine and integration with Power System And utilization of the same in power/control applications
2. Simulating Power Quality events (sag swell, harmonics) in PSCAD/EMTDC.
3. Analysis of the power quality events in PSCAD/EMTDC interfaced with MATLAB.
4. M- file code generation and implementation for the power & control Applications.

SEMESTER - II

MEE3201 APPLICATION OF AI IN POWER & CONTROL

Course Objective:

This course provides an overview of application of artificial Intelligence. Techniques include different applications of artificial Intelligence in power system and control.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the variety of different types of application of artificial Intelligence.
2. To understand the role of different techniques in the field of artificial Intelligence in power system and control.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction of soft computing, Soft computing vs. hard computing, Various types of soft computing techniques, Applications of soft computing, Introduction to Artificial Intelligence, Search Techniques knowledge representation issues.	30 Hours	1
II	**Fuzzy Logic:** Fuzzy set theory, Classical set theory, Crisp & Non-crisp set, Fuzzy set versus crisp set, crisp logic, fuzzy logic, Capturing uncertainty, Definition of fuzzy set, Graphic Interpretations, Fuzzy set -Small, Prime numbers, Universal space, Empty. **Fuzzy operations:** Inclusion, Equality, Comparability, Complement, Union, Intersection, introduction & features of membership functions.	30 Hours	1
III	**Neural Network:** Biological model, Information flow in neural cell, Artificial neuron, Functions, Equation, Elements, Single and Multi-layer Perceptrons. Structure and Function of a single neuron, Biological model, Information flow in neural cell, Characteristics and applications of ANN.	30 Hours	1
IV	**Genetic algorithm:** Fundamentals, basic concepts, working principle, Mechanics of Biological evolution; Artificial Evolution and Search Optimization, Taxonomy of Evolution & Search optimization - Enumerative, Calculus-based and Guided random search techniques, Evolutionary algorithms (EAs), Definitions of ART and other types of learning; ART, Description, Model functions, Training, and Systems,	30 Hours	1

	encoding, fitness function. **Associative Memory:** Description of AM; Examples of Auto and Hetero AM. **Adaptive Resonance Theory:** Definitions of ART and other types of learning; ART, Description, Model functions, Training, and Systems.		

Text & Reference books:

1. ‘Principles of Soft Computing’ by S.N.Sivanandam & S.N. Deepa, Wiley Publications.
2. ‘Artificial Intelligence’ by Rich E and Knight K TMH, New Delhi.
3. ‘Neural Network fundamental with Graph’ by Bose, TMH.

MEE3202 ECONOMIC OPERATION & CONTROL OF POWER SYSTEM

Course Objective:

This course provides an overview of economic operation and control of power system.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the variety of different types of controls in power system.
2. To understand the role of economic operation in power system.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Mathematical preliminaries of Optimization:** Unconstrained and constrained optimization for functions of Single and multiple variables, Techniques to search for optimal solutions, Linear programming, Dynamic programming. **Economic dispatch of thermal units:** Economic load dispatch of thermal units including network Losses, Transmission line loss calculation using B-coefficients, Optimization techniques to find economic dispatch. **Unit commitment:** Need for unit commitment, Constraints in unit commitment problem, Application of dynamic programming for solving unit Commitment problem.	30 Hours	1
II	**Load Frequency & Control:** Overview of the load frequency control problem, Development of prime mover, generator, turbine and load Models, Isochronous generators, Speed regulation characteristics, Load sharing by parallel generators, Adjusting speed-droop characteristics, tie-line model, Interconnected power system, Automatic generation control, generation allocation.	30 Hours	1

III	**Reactive power dispatch and optimal power flow:** Reactive power dispatch, Classical method, Derivation of the exact loss formula for transmission lines, Optimal reactive power dispatch using linear programming, Methods of reactive power control, Optimal power flow, Problem formulation for various objectives, Security constrained optimal power flow, Multi-contingency voltage stability enhancement, Multi-objective optimal power flow.	30 Hours	1
IV	**State estimation:** Power system monitoring, EMS, SCADA, Function of state estimator, Maximum likelihood estimation, Formulation of the WLS state estimator, DC state estimation. **Load Dispatch Centre Functions:** Contingency Analysis Preventive, Emergency and Restorative Control. **Hydrothermal scheduling:** Special characteristics of the hydrothermal scheduling problem, Short-term and long-term scheduling, Formulation of the short-term scheduling problem.	30 Hours	1

Text &Reference books:

1. Power system analysis by Nagrath and Kothari
2. Power Generation Operation and Control, by A.J. Wood and B.F. Wollenberg, John Wiley & Sons.

MEE3251 ARTIFICIAL INTELLIGENCE LAB

1. Study and utilizing of MATLAB toolboxes for power & control applications in ANN.
2. Study and utilizing of MATLAB toolboxes for power & control applications in Fuzzy model for classification/regression analysis
3. Study and utilizing of MATLAB toolboxes for power & control applications in Genetic Algorithm (GA) for optimization.
4. Study of example through MATLAB based on:
    - i. ANN.
    - ii. Fuzzy.
    - iii. GA.
5. Developing programs for non-conventional optimization methods including Bacteria Forging, Particle Swarm Optimization.
6. Developing M-programs for ANN, Fuzzy Logic, and GA.

GENERIC ELECTIVE-I

GE35011 DEREGULATION OF POWER SYSTEM

Course Objective:

1. The subject gives the knowledge about deregulation of power system.
2. To give the students a fair knowledge in deregulation field.

Learning Outcome:

At the end of the course, student should be able:

1. To analyze the Restructuring Models and Trading Arrangements and System Operator (SO).
2. To analyze in detail and understand about Different Models of Deregulation, Operation and control.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Fundamentals of Deregulation:** Motivations for Restructuring the Power Industry, Restructuring Process-Unbundling & Privatization, Wholesale and Retail Competition Market Entities.	30 Hours	1
II	**Restructuring Models and Trading Arrangements:** Components and Models of Restructured Electricity Markets. **System Operator (SO):** Functions and Responsibilities, Trading Arrangements (Pool, Bilateral & Multilateral), Open Access to the transmission system.	30 Hours	1
III	**Different Models of Deregulation:** UK Model, California Model**,** Australian and New Zeeland Models**,** Deregulation in Asia including India.	30 Hours	1
IV	**Operation and control:** Old vs New, Bidding strategies, Forward and future Market, Market Power, Available Transfer Capability, Congestion Management, Ancillary Services.	30 Hours	1

Text &References Books:

1. ‘Power System Restructuring: Engineering and Economics’ by M. Ilic, F. Galiana and L Fink, Kluwer Academic Publishers.
2. ‘Restructured Electrical Power Systems’ by M. Shahidehpour and M. Alomoush, Volatility, Marcel Dekker Inc.

3. Power System Restructuring and Deregulation, by L.L. Lie, John Wiley & Sons, UK.
4. Operation of Restructured Power Systems, by K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, Kluwer Academic Publishers, USA.
5. "Understanding Electric Utilities and Deregulation", by L. Philipson and H.L. Willis, Marcel Dekker Inc.

GE35012 HIGH VOLTAGE DC TRANSMISSION SYSTEM

Course Objective:

1. The subject gives the knowledge about high voltage DC.
2. To give the students a fair knowledge in the field of DC transmission.

Learning Outcome:

At the end of the course, student should be able:

1. To analyze the Phase controlled rectifiers & HVDC Control and Protection.
2. To analyze in detail and understand about harmonic analysis & recent Scenarios:

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Review of power electronic components: Thyristor, MOSFET, IGBT, comparison between HVAC and HVDC. **Transmission schemes:** Monopolar, bipolar, back to back, Multiterminal.	30 Hours	1
II	**Phase controlled rectifiers:** Thyristorised phase controlled rectifiers and dual converters, Operating principle, Characteristics, Control circuits, Commutation, End effect of source inductance.	30 Hours	1
III	**HVDC Control and Protection**: Alpha minimum characteristics, Constant current characteristic at rectifier, Constant extinction angle characteristics at rectifier, Alpha minimum at inverter, Current margin, Active power control, Current control amplifier (CCA), Commutation failure prevention control, Equidistant firing control.	30 Hours	1
IV	**Harmonic analysis**: Harmonic analyzer, THD, Distortion factor (DF), Ripple factor, and Reactive power requirement. **Filtering:** Active and passive, AC-DC system interaction. **Recent Scenarios**: HVDC schemes in India and worldwide, Research topics related to HVDC controls	30 Hours	1

Text &References Books:

1. Direct Current Transmission, Volume-1 by Edward Wilson Kimbark.
2. High voltage direct current transmission by J. Arrillaga.
3. ‘HVDC power transmission system’ by K.R. Padiyar.
4. ‘HVDC and FACTS controller’ by V.K. Sood.

GE35013 DIGITAL SIGNAL PROCESSING & ITS APPLICATIONS

Course Objective:

1. To develop a strong foundation in the field of digital signal processing.
2. The subject gives the knowledge about applications of digital signal processing.

Learning Outcome:

At the end of the course, student should be able:

1. To understand about digital signal processing.
2. To apply concept of signal processing.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Basic elements of digital signal Processing: Concept of frequency in continuous time and discrete time signals, Sampling theorem, discrete time signals, discrete time systems, Analysis of Linear time invariant systems, Z transform, Convolution and correlation.	30 Hours	1
II	**Introduction to DFT**: Efficient computation of DFT , Properties of DFT , FFT algorithms Radix-2 and Radix-4 FFT algorithms , Decimation in Time, Decimation in Frequency algorithms, Use of FFT algorithms in Linear Filtering and correlation, STFT, Introduction to Wavelet Transform- CWT and DWT	30 Hours	1
III	**Structure of IIR**: System Design of Discrete time IIR filter from continuous time filter, IIR filter design by Impulse Invariance, Bilinear transformation, Approximation derivatives, Design of IIR filter in the Frequency domain. **Symmetric & Anti-symteric FIR filters:** Linear phase filter, Windowing technique, Rectangular, Kaiser Windows, and Frequency sampling techniques, Structure for FIR, systems.	30 Hours	1
IV	**Quantization noise** : derivation for quantization noise power , Fixed point and binary floating point number representation , comparison , over flow error , truncation error, co-efficient quantization error , limit cycle oscillation , signal scaling , analytical, model of	30 Hours	1

	sample and hold operations. **Recent Research topics**- Measurement, Estimation techniques.		

Text & Reference Books:

1. 'Digital Signal Processing Principles, Algorithms and Application' by John G Proakis and Dimtris G Manolakis, PHI/Pearson.
2. 'Discrete Time Signal Processing' by Alan V Oppenheim, Ronald W Schafer and John R Buck, PHI/Pearson Education.
3. 'Introduction to Digital Signal Processing' by Johny R.Johnson, Prentice Hall of India/Pearson Education.

GE35014 SMART GRID

Course Objective:

1. To develop a strong foundation in the field of Smart Grid.
2. The subject gives the knowledge of wide Area Measurement System.

Learning Outcome:

At the end of the course, student should be able:

1. To understand about Electric Grid.
2. To understand about Wide Area Measurement System.
3. To understand about Microgrids.
4. To understand about Smart Grid.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.	30 Hours	1
II	**Smart Grid Technologies-1:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.	30 Hours	1
III	**Smart Grid Technologies-2:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS),	30 Hours	1

	Phase Measurement Unit(PMU).		
IV	**Microgrid:** Microgrids and Distributed Energy Resources: Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources. Unit V Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring. Text Books:	30 Hours	1

Text & Reference Books:

1. "Integration of Green and Renewable Energy in Electric Power Systems", by Ali Keyhani, Mohammad N. Marwali, Min Dai Wiley
2. "The Smart Grid: Enabling Energy Efficiency and Demand Response", by Clark W. Gellings, CRC Press
3. "Smart Grid: Technology and Applications", by Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley
4. "Smart Grids", by Jean Claude Sabonnadière, Nouredine Hadjsaïd, Wiley Blackwell.

GENERIC ELECTIVE-II

GE35021 FLEXIBLE AC TRANSMISSION SYSTEM (FACTS) CONTROLLERS

Course Objective:

1. The subject gives the knowledge about FACTS.
2. To give the students a fair knowledge FACTS controllers.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the need for FACTS.
2. To learn shunt and series compensation techniques.
3. To learn about controlled voltage and face angle regulator.
4. To learn the concept of unified power flow controller.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction**: The concept of flexible AC transmission, reactive power control in electrical power transmission lines, uncompensated transmission line, series and shunt compensation. Overview of FACTS devices , Static Var Compensator (SVC) , Thyristor Switched Series capacitor (TCSC), Unified Power Flow controller (UPFC) , Integrated Power Flow Controller (IPFC).	30 Hours	1
II	**Static Var Compensator and application (SVC):** Voltage control by SVC, advantagesof slope in dynamic characteristics, influence of SVC on system voltage. Applications, enhancement of transient stability, steady state power transfer, enhancement of power system damping prevention of voltage instability.	30 Hours	1
III	**Thyristor Controlled Series Capacitor (TCSC) and applications:** Operation of the TCSC, different modes of operation, modeling of TCSC, variable reactance model, modeling for stability studies. Applications, improvement of the system stability, limit, enhancement of system damping, voltage collapse prevention.	30 Hours	1
IV	**Emerging FACTS controllers:** Static Synchronous, Compensator (STATCOM), operating principle, V-I characteristics, Unified Power Flow Controller (UPFC),	30 Hours	1

	Principle of operation - modes of operation, applications, modeling of UPFC for, power flow studies. **Coordination of FACT controller:** FACTs Controller interactions – SVC–SVC, interaction - co-ordination of multiple controllers using linear control techniques, Quantitative treatment of control coordination.		

Text & Reference books:

1. 'Thyristor – Based Facts Controllers for Electrical Transmission Systems' by MohMohan Mathur, R., Rajiv. K. Varma, an Mathur, R., Rajiv. K. Varma, IEEE press and John Wiley & Sons.
2. 'Flexible AC Transmission System' by A.T.John, Institution of Electrical and Electronic Engineers (IEEE).
3. 'Understanding FACTS Concepts and Technology of Flexible AC Transmission System' by Narain G.Hingorani, Laszio. Gyugyl, Standard Publishers, Delhi.

GE35022 ADVANCED POWER SYSTEM PROTECTION

Course Objective:

1. The subject gives the knowledge about advanced protection in power system.
2. To give the students a fair knowledge power system protection.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the need for protection.
2. To learn **fundamentals of protection.**
3. To learn about **numerical relaying**& t**ypes of relays.**
4. To learn the concept of **adaptive protection.**

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Fundamentals of Protection:** Protective Relaying - Qualities of relaying – Definitions, Codes- Standards; Characteristic Functions, Classification, Analog-digital- numerical. Fundamental principles of over-current protection in feeder and motor. Fundamental principles of distance relaying protection in transmission lines-zones of protection, out-of step protection. Fundamental principles of differential protection and application to transformer, bus bar and generator armature winding protection. Role of instrument transformers in protection, Relay co-ordination in transmission system.	30 Hours	1
II	**Numerical Relaying**: Introduction to Numerical relaying.DSP fundamentals like aliasing, sampling theorem. Discrete Fourier Transform and application to current and voltage phasor estimation. Basic elements of digital protection, Signal conditioning- conversion subsystems**,** Relay units-sequence networks-fault sensing data processing units, FFT and Wavelet based algorithms: least square and differential equation based algorithms, Travelling wave protection schemes.	30 Hours	1
III	**Types of Relays:** Relay Schematics and Analysis-Over Current Relay, Instantaneous/Inverse Time – IDMT, Characteristics; Directional Relays**,** Differential Relays, Restraining Characteristics, Distance Relays: Types- Characteristics.	30 Hours	1
IV	**Adaptive Protection:** Need of Adaptive Protection in	30	1

	the system, Techniques for adaptive strategies in distance protection, synchrophasor based adaptive protection schemes, Protection schemes, SCADA based protection systems- FTA**,** Testing of Relays.	Hours	

Text & Reference books:

1. Digital protection for power systems-IEE power series-15, by A T John and A K Salman Peter Peregrines Ltd, UK.
2. The art and science of protective relaying, by C.R. Mason, John Wiley &sons.
3. Numerical distance protection, by Gerhard Ziegler, Siemens.
4. Protective Relays, Volume -1&2, by A.R.Warrington, Chapman and Hall.
5. Power system protection static relays with microprocessor applications, by T.S. Madhav Rao, Tata McGraw Hill Publication.

GE35023 POWER QUALITY

Course Objective:

1. To study the various issues affecting Power Quality.
2. To learn about production, monitoring and suppression.

Learning Outcome:

At the end of the course, student should be able:

1. To study the production of voltages sags, interruptions and harmonics and methods of control.
2. To study various methods of power quality monitoring.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction**: Overview and definition of power quality (PQ), Sources of pollution, International power quality standards and regulations. **Power quality issues:** rapid voltage fluctuations voltage unbalance, voltage dips and voltage swells, short duration outages, sources of power quality events, solution at end user level- isolation transformer, Voltage regulator, static UPS, rotary UPS, active series compensator.	30 Hours	1
II	**Power system harmonics**: Harmonics analysis, harmonic sources- static converters, Transformer magnetization and nonlinearities, Rotating machines, arc furnaces, florescent lighting Effects of harmonics on Transformers, AC motors, Cables, protection devices, passive and active filtering	30 Hours	1
III	**Harmonic effects and measurement**: **I**nterference within the power system, interference with communication, harmonic measurement, power quality analyzer, transient disturbance analyzer, wiring and grounding tester, flicker meter	30 Hours	1
IV	**Power quality indices:** Distortion factor, THD, ripple factor, Custom power devices: voltage regulation using DSTATCOM, sensitive load protection using DVR, UPQC.	30 Hours	1

Text & Reference books:

1. Understanding power quality problems: Voltage sags and interruptions Math H. J. Bollen.
2. Power quality enhancement using custom power devices-Arindam Ghosh,Gerard Ledwich.
3. Understanding FACTS: concept and Technology of Flexible AC Transmission Systems- Narain G. Hingorani, Laszlo Gyugyi.

GE35024 POWER SYSTEM DYNAMICS & CONTROL

Course Objective:

1. To study the dynamic control.
2. To learn about power system dynamic control.

Learning Outcome:

At the end of the course, student should be able:

1. To study the transient stability & frequency control.
2. To study various small signal stability & voltage stability.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Frequency control:** Modelling of Synchronous Machine, Modelling of load, network and excitation system, Modelling of turbine and governing system, Mathematical Modelling of Multi Machine System, Automatic Generation Control of Single Area and Multi Area Systems, Static and Dynamic Response of AGC Loops.	30 Hours	1
II	**Transient Stability Problem:** Equal area criterion and its application to transient stability studies under common disturbances including short, Circuits, Critical clearing angle and critical clearing time, Numerical solution of swing equation by step-by-step Method, Multi machine Transient Stability, Numerical methods for solution of differential equations, Modified Euler Method, Runge – Kutta fourth order method, Factors affecting steady state and transient stabilities, Methods of improving steady state, dynamic and transient Stabilities, Series capacitor compensation of lines, Excitation control, Power stabilizing signals.	30 Hours	1
III	**Small Signal Stability:** Power System Model for Low Frequency Oscillation Studies, Rotor angular measurement, synchro phasor measurement, Eigen value Analysis, Improvement of System Damping with Supplementary Excitation Control, Standard models for PSS representation- Introduction to Sub Synchronous Resonance.	30 Hours	1
IV	**Voltage Stability Problem:** Real and Reactive Power Flow in Long Transmission Lines, Effect Of ULTC And	30	1

	Load Characteristics On Voltage Stability, Voltage Stability Limit, Voltage Stability Assessment Using PV Curves, System Modelling-Static and Dynamic Analysis-Voltage Collapse Proximity Indices, Voltage Stability Improvement Methods.	Hours	

Text & Reference books:

1. "Power System Stability and Control", BY P. Kundur, McGraw-Hill.
2. "Power System Control and Stability", by P.M Anderson and A.A Fouad, Iowa State University Press, Ames, Iowa.
3. "Electric Energy System Theory - an Introduction" – by Elgerd O.I, Tata McGrawHill.
4. "Power Generation Operation and Control", by Allen J.Wood and Bruce .F. Woolen berg, John Wiley &sons, New York.
5. "Computer Aided Power System Analysis and Control", by Mahalanabis A.K., Kothari. D.P. and Ahson.S.I., Tata McGraw Hill publishing Ltd.

GENERIC ELECTIVE-III

GE35031 INDUSTRIAL DRIVES & CONTROL

Course Objective:

1. To study the industrial drives.
2. To learn about drives and control.

Learning Outcome:

At the end of the course, student should be able:

1. To study dc motor drives, inverter PWM techniques.
2. To study ac motor drives.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Classification of Electric Drives, Requirements of Electric Drives, Some Applications Converters and control: Phase controlled converters, AC to DC converters, Types, Four quadrant operations.	30 Hours	1
II	**DC motor drives:** Speed-torque characteristics DC shunt, PMDC and series motors, Dynamic model, Speed and position control methods	30 Hours	1
III	**Inverters and PWM techniques**: voltage source inverters, current source inverters, PWM techniques, sine-triangle comparison, harmonic elimination, hysteresis current controllers, space vector PWM.	30 Hours	1
IV	**AC motor drives:** d-q model of induction motor, constant flux speed control structure, vector control model, vector control structure.	30 Hours	1

Text Books/References:

1. Power Electronics and Drives – Ned Mohan.
2. Power electronics circuits devices and application –M H Rashid
3. Power semiconductor drives- G. K. Dubey
4. NPTEL lecture series online available

GE35032 ROBUST & ADAPTIVE CONTROL

Course Objective:

1. To understands the concept of robust and adaptive control along with the structure of the same.
2. Analyzing the stability of linear as well as non-linear systems. To study stability of non-linear systems also.
3. To study the uncertainties present in the system and analysis of robustness.
4. To study the different adaptive control strategies and their robustness.

Learning Outcome:

1. To understand the concept of robust and adaptive control along with the structure of the same. Also the performance objectives and design constraints or the control engineers.
2. To understand the concept of Lyapunov stability theory for continuous as well as discrete time system and stability for varying time system also.
3. To understand the concept of different uncertainties present in the system and analysis of robustness.
4. To understand the concept of different adaptive control strategies and their robustness.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Overview of classical control, Introduction of robust control and Adaptive control schemes, Features of robust control, Relationship between Non- Adaptive, robust and Adaptive Control, Performance objectives and design constraints for the control engineers.	30 Hours	1
II	**Analysis Tools (Lyapunov's stability theory)**: Definition for continuous-time systems, Definition for discrete-time systems, Lyapunov stability theorems, Lyapunov's second method for stability, Stability for linear state space models, Stability for systems with inputs, Barbalat's lemma and stability of time-varying system.	30 Hours	1
III	**Introduction to Robust Control System:** Robust control system and system sensitivity, Analysis of robustness, Systems with uncertain parameters, types of uncertainties: additive and multiplicative with examples, Design of robust control systems using worse case	30 Hours	1

	polynomial and Routh-Hurwitz criteria.		
IV	**Types of Adaptive Control strategies**: Introduction, Gain Scheduling Regulators, Self-Tuning Regulators, Model Reference Adaptive Control-Robustness of adaptive systems to disturbance and measurement noise-Parameter convergence: persistent excitation- Parameter projection, e-modification, sigma-modification-Adaptive control in the presence of input saturation-Adaptive back stepping-Overview of adaptive output feedback control theory, L1 adaptive control: transient performance and robustness- Norms and gains for signals and systems-Small-gain theorem-Achievable performance: Reference system and guaranteed performance bounds-Design system and decoupled performance bounds- State feedback architecture-Output feedback architecture-Unknown high-frequency gain-Output feedback for non SPR reference systems.	30 Hours	1

Text/Reference Books:

1. Systems and Control, by S.H. Zak, Oxford Univ. Press, 2003.
2. Nonlinear Systems, by H.K. Khalil, Prentice Hall, N.J., 2002.
3. Essentials of Robust Control, by Kemin Zhou, Prentice Hall.
4. Robust Control Design, by Feng Lin, John Wiley & Sons, Ltd.

GE35033 INTELLIGENT INSTRUMENTATION

Course Objective:

1. To understand the concept of current trends in the instrumentation engineering.
2. To understand Lab-VIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. To understand the different Transducers, sensors and data acquisition in the instrumentation engineering.
4. To understand the structure and working of PC hardware and instrumentation busses.

Learning Outcome:

1. To concept of current trends in the instrumentation engineering.
2. To understand the concept of Lab-VIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. To understand the concept of different Transducers, sensors and data acquisition in the instrumentation engineering.
4. To understand the concept of Structure and working of PC hardware and instrumentation busses.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Virtual Instrumentation:** Introduction to instrumentation and intelligent instrumentation, Software based instruments, Introduction to data flow & graphical programming techniques, Evolution of Virtual Instrumentation. **Virtual Instrumentation**: Definition, Architecture, Advantage of VI techniques, Presentation, Control and Functional Integration, VIs and sub Vis, Loops and charts, arrays, clusters and graphs, case and sequence structure, formula nodes, string and file I/O, Code Interface Nodes and DLL link.	30 Hours	1
II	**Transducers:** Introduction to transducers, Electro mechanical transducers, Resistance, Inductance, Capacitive and Piezoelectric transducers, Thermoelectric and Photoelectric transducers, Analog and digital transducers including semiconductor and optical type, Application to measurement of temperature, Pressure, Flow, Displacement and other non-electrical quantities.	30 Hours	1
III	**Sensors and Data Acquisition:** Sensors, Introduction,	30	1

	Type of sensors, Sensor Standards and Protocols, Sensor Performance Characteristics, Intelligent Sensors. **Data Acquisition:** Introduction to data acquisition system, A/D and D/A converters, Sample and hold circuit, MUX and DEMUX, Signal transmission, Introduction to DAQ cards.	Hours	
IV	**PC Hardware Review and Instrumentation Buses:** Introduction, Structure, Timing and interrupts, DMA, operating system, ISA, PCI, USB and PCMCIA Buses, IEEE488.1 & 488.2 serial, Interfacing-RS 232C, RS422, RS423, RS485, USB, VXI, SCXI, PXI.	30 Hours	1

Reference/Text Books:

1. "Intelligent Instrumentation", by G. C. Barney, Prentice Hall, 1995.
2. Virtual Instrumentation using Labview, J.John, S Gupta.
3. Lab-VIEW based Advanced Instrumentation Systems, S. Sumathi and P. Surekha.
4. "Lab VIEW For everyone", by Lisa, K. Wells & Jeffery Travis, Prentice Hall, 1997.

GE35034 ROBOTICS

Course Objective:

1. To understand the concept of current trends in robotics engineering.
2. To understand Lab-VIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. To understand the different Transducers, sensors and data acquisition in the robotics engineering.
4. To understand the structure and working of robotics.

Learning Outcome:

1. To understand the concept of current trends in the robotics engineering.
2. To understand the concept of Lab-VIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. To understand the concept of different Transducers, sensors and data acquisition in the robotics engineering.
4. To understand the concept of concept of current trends in the Nano-robotics.
5. To understand the concept of concept of current trends in the Biomimetic-robot.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**INTRODUCTION:** Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems Specifications of Robot-Speed of Robot-Robot joints and links-Robot classifications Architecture of robotic systems-Robot Drive systems Hydraulic, Pneumatic and Electric system.	30 Hours	1
II	**END EFFECTORS AND ROBOT CONTROLS:** Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.	30 Hours	1
III	**ROBOT TRANSFORMATIONS AND SENSORS:** Robot kinematics-Types- 2D, 3D Transformation-Scaling, Rotation, Translation- Homogeneous coordinates, multiple transformation-Simple problems.	30 Hours	1

	Sensors in robot – Touch sensors-Tactile sensor – Proximity and range sensors – Robotic vision sensor-Force sensor-Light sensors, Pressure sensors. 4 RB-2013 SRM		
IV	**ROBOT CELL DESIGN AND APPLICATIONS:** Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot Mobile robot working principle, actuation using MATLAB, NXT Software Introductions-Robot applications Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot. **MICRO/NANO ROBOTICS SYSTEM:** Micro/ Nanorobotics system overview-Scaling effect-Top down and bottom up approach- Actuators of Micro/Nano robotics system-Nanorobot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles- Biomimetic robot-Swarm robot-Nanorobot in targeted drug delivery system.	30 Hours	1

Reference/Text Books:

1. Robotics Technology and flexible automation, by S.R. Deb, Tata McGraw-Hill Education., 2009
2. Industrial Robotics, Technology programming and Applications, by Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, McGraw Hill, 2012